AD_____

COOPERATIVE AGREEMENT NO: DAMD17-93-V-3018

TITLE: GEORGETOWN INSTITUTE FOR COGNITIVE AND COMPUTATIONAL SCIENCES

PRINCIPAL INVESTIGATOR: Robert S. Ledley
Alan I. Faden

CONTRACTING ORGANIZATION: National Biomedical Research Foundation
3900 Reservoir Road, N.W.
Washington, DC 20007

REPORT DATE: November 4, 1994

TYPE OF REPORT: Annual Report

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick
Frederick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for public release;
distribution unlimited

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 4, 1994	Annual (10/1/93 - 9/30/94)

4. TITLE AND SUBTITLE
Georgetown Institute for Cognitive and Computational Sciences

5. FUNDING NUMBERS
Cooperative Agreement
DAMD17-93-V-3018

6. AUTHOR(S)
Robert S. Ledley
Alan I. Faden

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Biomedical Research Foundation
3900 Reservoir Road, N.W.
Washington, DC 20007

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
Fort Detrick
Frederick, Maryland 21702-5012

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Georgetown University Medical Center has established a Department of Neuroscience to provide the optimal academic structure to support the Georgetown Institute for Cognitive and Computational Science (GICCS). Several experts in the field were invited to participate in the planning, organization and recruitment of the chair and faculty for the Department of Neuroscience. The chair of this department is being actively recruited; final candidates have been identified and this process is entering its final stages. In addition, we have advertised for faculty positions for GICCS; 42 applications have been received to date. An administrator of the Institute has been hired. The scientific project entitled "Texture Analysis for Scene Segmentation" led by Dr. Robert S. Ledley has begun. This study will provide an important tool to explore various aspects of biological pattern recognition.

14. SUBJECT TERMS
Pattern recognition, Memory and Learning, Texture analysis, Cognitive neurosciences, Computational sciences

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

Accesion For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.

( ) Where copyrighted material is quoted, permission has been obtained to use such material.

( ) Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

( ) Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

( ) In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council (NIH Publication No. 86-23, Revised 1985).

( ) For the protection of human subjects, the investigator(s) have adhered to policies of applicable Federal Law 45 CFR 46.

( ) In conducting research utilizing recombinant DNA technology, the investigator(s) adhered to current guidelines promulgated by the National Institutes of Health.

NONE OF THE ABOVE APPLY

Principal Investigator's Signature

Alan I. Faden, M.D.
November 4, 1994

Cooperative Agreement No. DAMD17-93-V-3018

TABLE OF CONTENTS

INTRODUCTION

The ability of existing computer systems to learn to discriminate patterns has been limited despite rapid increases in computational power. In contrast to learning abilities of the mammalian brain, computers are only able to acquire patterns that have first been learned and stored; having been programmed, computers can collect and perform the necessary complex operations on generally narrowly specified types of patterns. Recent insights into the molecular and synaptic structure of brain networks have begun to be incorporated into the development of artificial computer-based networks. Such biologically based pattern recognition principles can permit the development of a new generation of computers than can, to a certain extent, be self programming. Moreover, the exploration of biological networks, including parallel basic and applied research studies, can help to expand our knowledge of human brain functions and behavior.

DEVELOPMENT OF AN INSTITUTE FOR COGNITIVE AND COMPUTATIONAL SCIENCES

The Georgetown Institute for Cognitive and Computational Sciences (GICCS) has been established to study processes of pattern recognition and storage - including sensation, perception, learning and memory - from the molecular level to the operation of the complex brain networks. It is intended that the Institute will have three general research sections.The first section will focus on the cellular and molecular mechanisms of learning and memory with particular reference to understanding the nature of biological networks. The second will focus on the development of artificial neural networks based on biological principles. The third section will utilize molecular and second messenger concepts to develop novel brain imaging techniques that will relate both to the biologic and artificial neural network components. Additionally, it is intended that the Institute will interface more broadly to other relevant neuroscience areas including electrophysiology (particularly relating to ion channels and receptors); molecular neurobiology (including signal transduction mechanisms); neuropharmacology (with particular reference to ligand receptor interactions and to cognitive function); and, to computational physics and computer sciences.

Although the primary mission of the Institute is theoretical and experimental research, there is also an explicit commitment to develop relevant clinical and commercial applications that derive from these research efforts. Through this commitment, the Institute will serve as a catalyst for development and/or expansion of complementary research programs at the medical center and the main campus in such areas as neuroscience, developmental biology, computational physics, applied mathematics, and computer sciences. The Institute will also provide opportunities for graduate and undergraduate students who wish to pursue research in these areas.

In order to maximally promote the development of the goals of the Institute, it has been proposed that the medical center develop the relevant departmental structure (i.e., a Neuroscience Department) to provide an academic home for key scientists recruited into the Institute. This would serve to provide for longer term security such as tenure track appointments as well as to provide an effective forum for the involvement of faculty in

other university-wide activities. This concept of a Neuroscience Department was reviewed and approved by the executive faculty of the Medical Center, the Medical Center Council, and the Committee on Medical Center Affairs of the Board of Directors of the University. Additionally, an interdisciplinary doctoral training program was recently established at the university that will promote interdisciplinary neuroscience research in related areas.

The second step has been to recruit a chair of the Neuroscience Department with specific expertise in cognitive and/or computational neuroscience. Four final candidates have been submitted by the search committee, three of whom are members of the National Academy of Sciences. Discussions are actively underway with several of these individuals and it is anticipated that a chair will be selected within the next six to eight weeks.

In addition to searching for a chair of the department who would also likely serve to direct the Institute, we have advertised in *Science Magazine*, *Nature Magazine* and the *Neuroscience Newsletter* for faculty for the new Institute. A total of 42 applications have been received, including individuals at both junior and senior levels. Candidates have been ranked in terms of qualifications and we are awaiting the appointment of the chair and Institute director to begin aggressive recruitment of these individuals.

In order to develop the optimal structure for the Institute and to help to identify key scientists, we have invited several experts to Georgetown University to review plans for the development of the Institute and the recruitment of faculty. These individuals, Charles M. Bachmann, Ph.D., Research Physicist, Radar Division, Naval Research Laboratory; John A. Disterhoft, Ph.D., Professor, Department of Cell, Molecular and Structural Biology, Northwestern University Medical School; Michael E. Hasselmo, D.Phil., Professor, Department of Psychology, Harvard University; Shihab A. Shamma, Ph.D., Associate Professor, Department of Electrical Engineering, University of Maryland, have also presented university-wide seminars to educate the community about the fields of cognitive and computational sciences.

An Internal Advisory Board has been established to contribute to the development of the Georgetown Institute for Cognitive and Computational Sciences. The Board has held two

meetings thus far and will continue to meet on an ongoing basis to make recommendations concerning the goals and objectives related to the recruitment and scientific focus of the Institute. Its members include: Robert S. Ledley, D.D.S., President and Director of the National Biomedical Research Foundation; Robert L. Martuza, M.D., Chair, Department of Neurosurgery, Georgetown University; Martin Morad, Professor, Department of Pharmacology, Georgetown University; Joseph Serene, Ph.D., Chair, Department of Physics, Georgetown University; Rene Etcheberrigaray, Ph.D., NINDS, NIH; Daniel Alkon, Ph.D., NINDS, NIH; and James Olds, Ph.D., NINDS, NIH.

A search was also undertaken to recruit a senior administrator for the Institute, one ideally with previous experience in neuroscience. We were most fortunate in being able to hire Loretta Ostmann,who during the past four years had served as administrator for the Fidia-Georgetown Institute for Neurosciences.

SCIENTIFIC PROJECTS

As indicated above, a major goal of the Institute will be to better understand biologically based pattern recognition from early processing events in the eye to the level of associative learning at the sub-cellular, cellular, and network levels. Among the intermediate steps in visual processing is the role of the lateral geniculate and visual cortex in pattern recognition. One such role is the splitting of visual information into spatial frequency bands and the utilization of this splitting in terms of texture recognition. Thus, image areas that differ solely by texture have the same mean luminance and therefore need to be distinguished on the basis of other properties. Among such properties is the two-dimensional spatial frequency content of the area. One approach to texture segmentation is to decompose an image into multiple sub-band images, each representing the energy within a particular two-dimensional spatial frequency band. This permits identification of regions within the image having the same texture. That is, it allows segmentation of the image. Because such image regions often show a one-to-one correspondence with objects or components of objects within the image, texture segmentation can be a useful method for extracting image regions that may be used for object recognition.

Dr. Robert S. Ledley, President and Director of the National Biomedical Research Foundation and Professor of Physiology and Biophysics at Georgetown University, has begun a project to study texture recognition. A variety of approaches need to be explored because of the importance of texture classification in the overall process of pattern recognition. Many currently used frequency decomposition techniques use Gabor filters to generate sub-band images, the Gabor filter being a model of simple cells of the human visual cortex. In contrast, Dr. Ledley is exploring an alternate approach using the Discrete Cosine Transformation (DCT) in a study supported as a subgrant to the Institute. This project entitled "Texture Analysis for Scene Segmentation" uses the well known DCT image compression algorithm to generate sub-band images for texture segmentation. The advantage of the DCT method over Gabor filters is that the DCT is an orthogonal basis set. In this regard, Dr. Ledley and coworkers have developed several software programs to calculate the DCT of an image. These have been designed to allow flexibility with regard to

the size of the DCT to be performed, the type of output and the type of interaction with the user. Thus, the availability of the set of texture measures being developed by Dr. Ledley should serve as a useful tool for other scientists at the Institute as they explore various aspects of biological pattern recognition. To date, Dr. Ledley has purchased the necessary hardware and software to perform the requisite measurements, developed several software routines to calculate the DCT of an image and begun the process of acquiring evaluation textures. In the latter regard, he has purchased a volume of standard natural textures and has begun to digitize the Brodatz textures with a photographic scanner. The acquisition of these textures should allow them to compare the performance of developed routines with other already-published routines and will also permit the validation of the newly developed routines in published results.

CONCLUSIONS

In the first year, considerable effort has gone into establishing the optimal academic and support environment for the smooth functioning of the Georgetown Institute for Cognitive and Computational Sciences. A Neuroscience Department is being established to serve as an academic home for Institute scientists. It is intended that the department chair will serve as the Institute director or will rapidly appoint such a director. The search for the chair of the department is entering its final stages. In order to prepare for rapid recruitment of faculty, advertisements regarding potential faculty positions have been published in leading journals and a number of excellent candidates have applied. Outside consultants have been brought in to provide suggestions regarding the organizational structure of the Institute and for recommending potential faculty members. An experienced administrator for the Institute has now been appointed and the first scientific project has been initiated. It is anticipated that additional projects will be initiated in the near future as faculty are recruited.